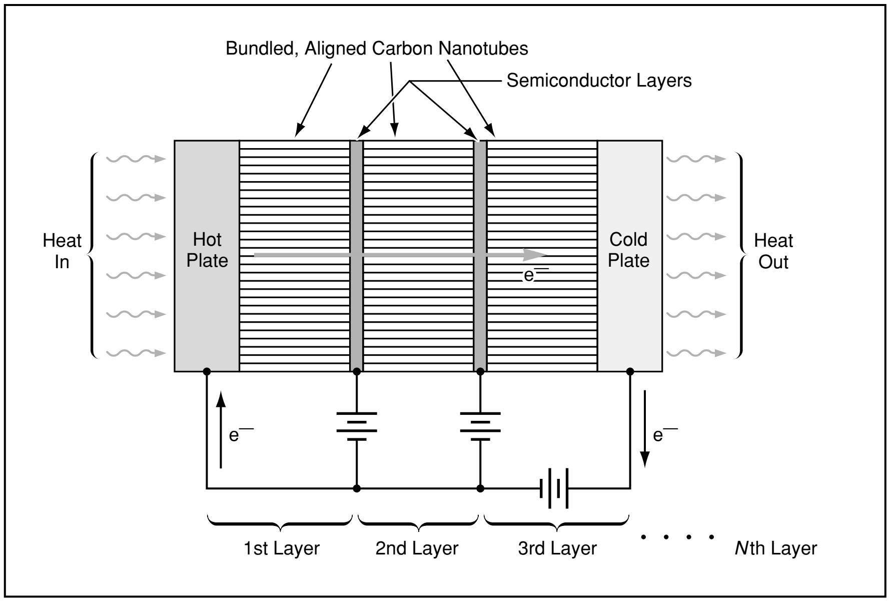


0A **TEB Device** would exploit thermionic emission, ballistic transport of electrons in carbon nanotubes, and Schottky barriers at nanotube/semiconductor interfaces. The thickness of each nanotube layer would be of the order of 5 µm.

with *N* – 1 semiconductor layers; an electrically and thermally conductive plate, denoted the cold plate, on the side to which heat is to be transferred; and small batteries or other DC electric power sources and wiring connected to the hot and cold plates and to the semiconductor layers. Under the influence of the electric potential field applied by the DC sources, some of the thermally agitated electrons would be adiabatically swept away from the hot plate into the first layer of nanotubes. (Because of this mode of operation, the device could also be called a thermionic cooler or heater.) The applied electric field would accelerate the electrons moving in the nanotubes, giving them enough kinetic energy to overcome the Schottky barrier at the nanotube/semiconductor interface. Consequently, the Schottky barrier would act as a one-way valve for energetic electrons.

In the same manner as described above, thermally agitated electrons in each semiconductor layer would be made to travel through the next nanotube layer to the next semiconductor layer, and so forth until the electrons reach the cold plate, from whence they would be removed via an ohmic contact into the wiring. The closed electric circuit would maintain charge neutrality, supplying electrons to the hot plate and semiconductor layers to replace those removed by thermionic emission and applied electric fields. In addition to a DC potential applied between the hot and cold plates, DC bias potentials could be applied to the semiconductor layers to control the quantum-mechanical tunneling of electrons through the Schottky barriers.

It will be necessary to perfect a number of techniques in order to fabricate TEB devices. Among these are techniques for (1) depositing RTSPs or growing highly pure, aligned single-wall carbon nanotubes on electrically and thermally conductive substrates that can serve as hot and cold plates; (2) cutting the nanotubes to make clean, flat planes on which semiconductor layers can be deposited; and (3) depositing RTSPs or growing highly pure, aligned single-wall carbon nanotubes on the semiconductor layers. The overall thickness of a TEB device would be determined largely by the number of carbon-nanotube layers, the length (≈5 µm) of the nanotubes in each layer, and the thicknesses of the semiconductor layers. It should be possible to make TEB devices so thin that they could be incorporated into or onto flexible structures.

This work was done by Sang H. Choi of **Langley Research Center**. *Further information is contained in a TSP [see page 1].*
LAR-16222

Optoelectronic Apparatus Measures Glucose Noninvasively

The concentration of glucose is obtained through a combination of interferometry and polarimetry.

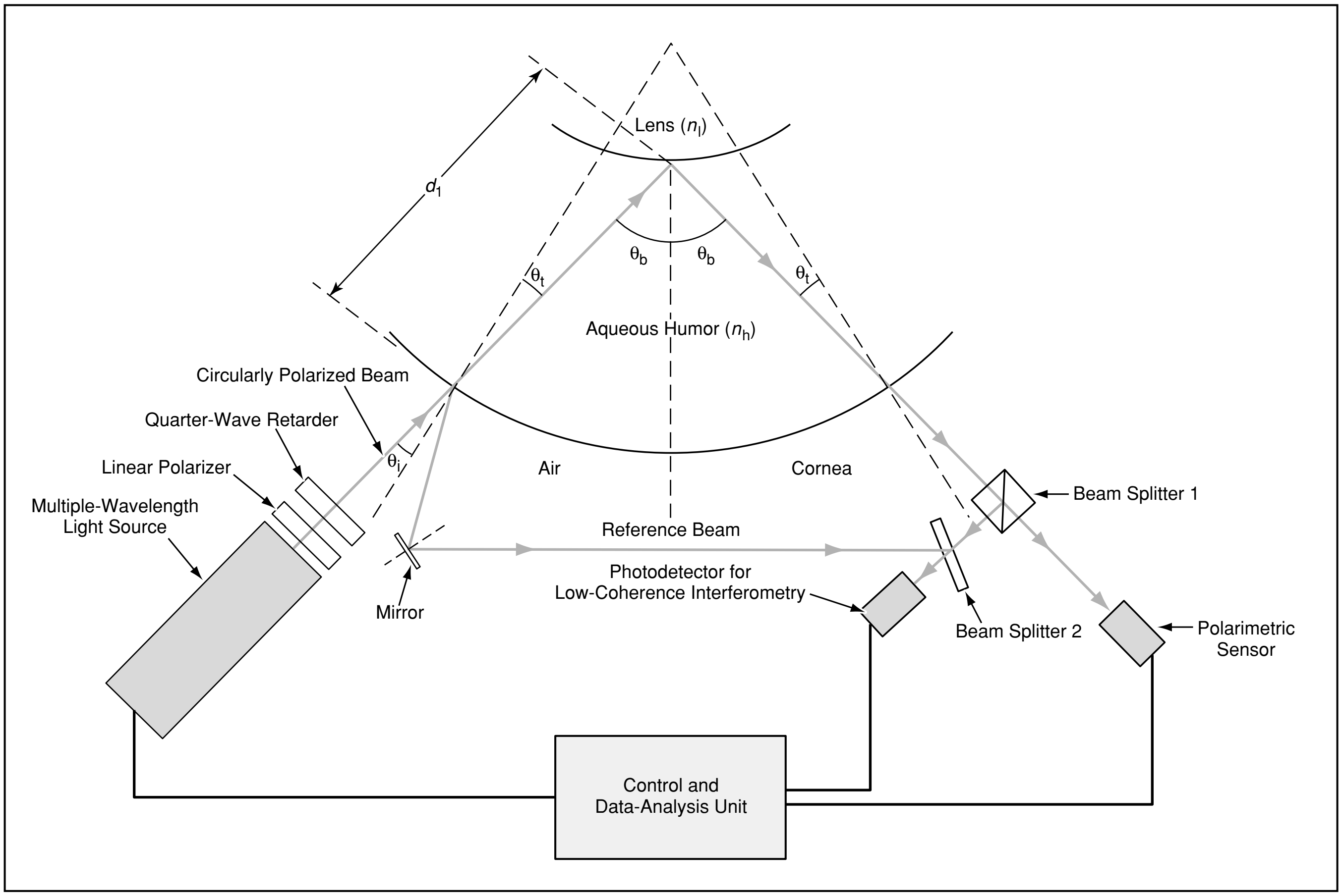
John H. Glenn Research Center, Cleveland, Ohio

An optoelectronic apparatus has been invented as a noninvasive means of measuring the concentration of glucose in the human body. The apparatus performs polarimetric and interferometric measurements of the human eye to acquire data from which the concentration of glucose in the aqueous humor can be computed. Because of the importance of the concentration of glucose in human health, there could be a large potential market for instruments based on this apparatus.

The apparatus (see figure) includes a light source equipped with a linear polarizer and a quarter-wave retarder to generate a beam of circularly polarized light. The beam is aimed at an eye at an angle of incidence (θ_i) chosen so that after refraction at the surface of the cornea, it travels through the aqueous humor and impinges on the crystallin lens at the Brewster angle [$\theta_b = \arctan(n_l/n_h)$, where n_l and n_h are the indices of refraction of the lens and the aqueous humor, respectively]. The portion of the beam that enters and passes through the eye is denoted the probe beam. The portion of the beam reflected from the cornea is further reflected by a mirror and used as a reference beam for low-coherence interferometry.

The Brewster-angle arrangement causes the portion of the probe beam reflected from the lens to be linearly polarized perpendicular to the plane of incidence (which here coincides with the plane of the page). As the reflected probe beam traverses the aqueous humor, glucose molecules rotate its plane of polarization. This rotational effect is well established: It is characterized by previously determined, wavelength-dependent proportionality between (1) the angle of rotation of the plane of polarization and (2) the product of the concentration of glucose and the length of the optical path through the solution (in this case, aqueous humor) that contains the glucose. Hence, if one can measure the rotation of polarization of the reflected light and the length of its path through the aqueous humor, one can calculate the concentration of glucose by use of the aforementioned proportionality.

After leaving the eye, the reflected probe beam enters beam splitter 1. Part of the probe beam passes through beam splitter 1 and goes to a polarimetric sensor, which



Light Beams Are Reflected and Transmitted by several components of the eye. The polarimetric and interferometric properties of the reflected and transmitted beams contain information on the concentration of glucose in the aqueous humor.

measures its angle of polarization. From this angle and the known orientation of the plane of incidence on the lens, the rotation angle can be determined. Part of the probe beam leaving the eye is reflected from beam splitter 1 toward beam splitter 2, wherein it is combined with the reference beam. The combination of the probe reference beams impinges on a photodetector for use in low-coherence interferometry to measure the total length of the path of the probe beam through the aqueous humor. By virtue of symmetry, half of this path length contributes to the measured rotation and is, therefore, the length to use in calculating the concentration of glucose.

As described thus far, the principle of operation does not necessarily involve the use of multiple wavelengths. The value of multiwavelength operation lies in the possibility of compensating for rotation caused by analytes other than glucose. By measuring at a number of wavelengths equal to the number of analytes (including glucose) that contribute to rotation and knowing the wavelength-dependent specific rotation, one can solve the system of linear equations for the rotation at the various wavelengths to extract the concentration of glucose (and, incidentally, of the other analytes).

This work was done by Rafat R. Ansari of **Glenn Research Center** *and Luigi L. Rovati of the University of Brescia. Further information is contained in a TSP [see page 1].*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17216.

Floating Probe Assembly for Measuring Temperature of Water

Temperatures are measured at several depths.

Stennis Space Center, Mississippi

A floating apparatus denoted a temperature probe aquatic suspension system (TPASS) has been developed for measuring the temperature of an ocean, lake, or other natural body of water at predetermined depths. These types of measurements are used in computer models to relate remotely sensed water-surface temperature to bulk-water temperature. Prior instruments built for the same purpose were found to give inaccurate readings because the apparatuses themselves significantly affected the temperatures of the water in their vicinities. The design of the TPASS is intended to satisfy a requirement to minimize the perturbation of the temperatures to be measured.

The TPASS (see figure) includes a square-cross-section aluminum rod 28 in. (≈71 cm) long with floats attached at both ends. Each float includes five polystyrene foam disks about 3/4 in. (≈1.9 cm) thick and